DOCUMENT RESUME

ED 253 417 SE 045 384

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TITLE The Path from Algebra I to Geometry to Algebra II to Developmental Studies Mathematics.
PUB DATE Sep 84
NOTE 11p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Algebra; *College Mathematics; Developmental Studies Programs; Educational Research; Error Patterns; Higher Education; Mathematics Curriculum; *Mathematics Instruction; *Remedial Instruction; *Testing
IDENTIFIERS Georgia; *Mathematics Education Research

ABSTRACT

Nearly 48 percent of the students in Developmental Studies Mathematics courses at a major southern university during the fall of 1983 had taken college preparatory mathematics courses in high school. Some had even taken trigonometry, pre-calculus, or calculus. Yet, they were placed in university developmental studies mathematics courses because they had not met the university's criteria for regular admission (based on a sliding scale of SAT scores and high school grade point averages). These students were administered the Intermediate Algebra Skills test developed by the College Board. An item analysis was conducted to determine what algebraic skills these students lacked after nearly four years of college preparatory mathematics. More than 50 percent of these students could not solve problems involving recall of a formula or standard form such as the quadratic equation, slope of a line, the distance formula, or the slope-intercept of a line. It is recommended that high school students be provided an ongoing review of algebraic formulas (particularly linear and quadratic equations) and afforded ample opportunities to apply these formulas in problem solving situations. (Author)

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The Path from Algebra I to Geometry to Algebra II to Developmental Studies Mathematics

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Author Abstract

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Nearly 48 percent of the students in Developmental Studies Mathematics courses at a major southern university during the fall of 1983 had taken college preparatory mathematics courses in high school. Some had even taken trigonometry, pre-calculus, or calculus. Yet, they were placed in university developmental studies mathematics courses because they had not met the university's criteria for regular admission (based on a sliding scale of SAT scores and high school grade point averages).

These students were administered the Intermediate Algebra Skills test developed by the College Board. An item analysis was conducted to determine what algebraic skills these students lacked after nearly four years of college preparatory mathematics.

More than 50 percent of these students could not solve problems involving recall of a formula or standard form such as the quadratic equation, slope of a line, the distance formula, or the slope-intercept of a line.

It is recommended that high school students be provided an ongoing review of algebraic formulas (particularly linear and quadratic equations) and afforded ample opportunities to apply these formulas in problem solving situations.

Information About Document: Journal Article

Blackburn, K. T. (1984, September). The path from algebra I to geometry to algebral II to developmental studies. Reflections, 32, 9-12.

Recent reports such as A Nation at Risk, by the National Commission on Excellence in Education, have focused on the low achievement of public school students in mathematics. These reports have expressed concern both in terms of basic mathematical skills and of implications for future study at the college or university level.

Since a number of students entering college do not possess the knowledge and skills necessary for higher education, colleges and universities have created developmental studies programs. Between the years of 1975 and 1980, enrollments in remedial or developmental courses at the university or college level increased by an alarming 72 percent. Over 80 percent of American colleges and universities currently provide remedial courses in basic skills, including the University of Georgia.

The University of Georgia's Developmental Studies Program was started in 1976. Its aim is to provide high-school graduates who do not meet regular admission criteria with the skills to achieve su ssfully in the university environment.

Developmental Studies students enrolled in mathematics courses are often stereotyped as very deficient in mathematics skills. Often, it is assumed that these students have probably had only general mathematics or pre-algebra in high school, having taken the minimum requirement for graduation. While this is true for some, shockingly it is not true for a significant number of other students. Surprisingly, nearly 40 percent of the students in Developmental Studies mathematics courses at the University of Georgia (UGA) during the fall of 1983 had taken college preparatory

mathematics courses beginning with first-year algebra and continuing on through geometry and second-year algebra. A number of these students had taken trigonometry, pre-calculus, or even calculus. These students had taken appropriate, even higher level, mathematics courses during their high-school years and yet ended up in Developmental Studies mathematics at the university level, a situation most surprising, disappointing, and expensive to them and their parents.

The purpose of this article is to examine specific mathematical skill deficiencies of those students who should have been qualified to take regular university freshman mathematics courses for credit, but instead were placed in non-credit Developmental Studies mathematics courses.

It is important to understand how students are placed in Developmental Studies mathematics courses. Students who have not met the UGA criteria for regular admission (based on a sliding scale of SAT scores and high-school grade point averages) are referred to the Division of Developmental Studies if they have (1) at least a 650 SAT composite score and a 2.0 adjusted high-school grade point average or (2) have the status of minority, local, or grant-in-aid applicant.

Placement and exemption from Developmental Studies mathematics courses is based upon scores on two different tests: The University System of Georgia Basic Skills Examination Mathematics Test (BSEM), developed by the Board of Regents of the UGA system, and the Intermediate Algebra Skills (IAS), a descriptive test of mathematics skills developed by the College Board. A student is exempt from the Developmental Studies mathematics program if he or she scores 80% or better on the former and 70% or better on the latter.

During the fall quarter of 1983, 232 students were enrolled in Developmental Studies mathematics courses at the University of Georgia. Of these students, 37% were placed in the most advanced of the three levels of mathematics courses offered in the Division of Developmental Studies (Mathematics 098*M), and it is this group of students who will be the focus of this report. This particular group of students had an average of 3.7 high-school mathematics courses, beginning with first-year algebra. The mean of their SAT mathematics scores was 450.72 with a standard deviation of 55.43. The mean of their scores on the BSEM was 87.35 with a standard deviation of 5.52, and the mean on the IAS was 55.93% with a standard deviation of 2.45. (If they had scored at least 70% on the IAS, they would have been exempt from Developmental Studies mathematics.) The mean of their high-school grade point averages was 2.52 with a standard deviation of .405. The descriptive statistics on the placement tests used are presented in Table 1.

Ninety-six percent of these students were from Georgia, and 72% attended Georgia public high schools. Forty-nine percent of the students attended large Georgia high schools (2,000 or more students) as shown in Table 2.

I conducted an item analysis on the IAS in an effort to determine what specific algebraic skills these students in the 098*M classes still lacked after nearly four years of college preparatory mathematics. Seventy-seven percent of these students could not determine the equation of a line perpendicular to a given line through a given point. Seventy-four percent failed to derive the equation of a line when give the slope and a point on the line. Seventy percent were unable to select an equation of a line parallel to a given line through a given point. Between 60% and 70% of the

Table 1

Means and Standard Deviations of Tests or other Placement Criteria of Developmental Mathematics 098* Studerts at the Unviersity of Georgia during the Fall, 1983

Test or other placement criteria	n = 83	$\bar{X}$	s
SAT mathematics		450.72	55.43
BSEM		87.35	5.52
IAS		55.93	2.45
Number of high-school mathematics courses		3.7	.89
High-school grade point average		2.52	.405

Table 2

Types of High Schools Attended by Students Enrolled in Developmental Studies Mathematics 098* at the University of Georgia, Fall, 1983

Type of school	Percentage of students
Georgia public high schools	
Student enrollment	
3000-3499	10
2500-2999	10
2000-2999	29
1500-1999	17
1000-1499	06
Fewer than 1000	01
Georgia private high schools	23
Out-of-state high schools	04

students could not solve equations requiring recall of the quadratic formula, nor find the distance between two points, nor find the slope of a line when given two points. Table 3 shows items missed by 50% or more of the students.

Table 3

Items Missed on the Intermediate Algebra Skills Test by 50% or More of the Students Enrolled in 098* Mathematics during Fall Quarter, 1983

Item missed	Percentage of students
Finding the equation of a line perpendicular to a given line and through a given point	77
Finding the equation of a line when given the slope on the line	74
Adding or subtracting fractions containing algebraic expressions	71
Graphing quadratic equations	71
Finding the equation of a line parallel to a given line through a given point	70
Solving an equation using the quadratic formula	67
Finding the distance between two points	66
Finding the slope of a line when given two points on the line	62
Graphing linear equations	57
Solving equations containing fractions with algebraic expressions in the denominator or numerator	51
Finding the y-intercept of a line when given the equation of the line	50

An interesting pattern one observes is that students could not do problems which involved recall of a formula, such as

$$y = mx + b$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$m = (y_2 - y_1)/(x_2 - x_1)$$

These developmental studies students, who have taken college preparatory high-school mathematics courses, still cannot do problems involving linear quadratic equations and other problems whose solution depends on the knowledge of a specific formula or a standard form.

There are several possible explanations for this. One is that students merely memorized a formula long enough to take a test. In other words, they committed the formula to rote memory, never really learning the concept. A second possible explanation is that they understood the generalization during instruction, but after the instructional unit had been completed, the student had neither the opportunity or the need to use it again. This brings to mind the adage, "Use it or lose it."

The mathematics staff in the Division of Developmental Studies, after having taught these students for a full quarter, feel that the low scores of the IAS are the result of a combination of the two factors. These students seem to be very proficient at performing algebraic manipulations. If given a formula, they do quite well in substituting numbers for variables. However, they cannot recall the formula itself. Moreover, they have no idea

how to derive the formula or even how logically to select an answer that makes sense. They do not understand the concept of a function, and they have little experience in applying what knowledge they have to practical situations.

These students missed other types of problems as well, such as solving an equation involving algebraic fractions, e.g., $(5x + 2 / (x - 1) + (3x + 2) / (x + 1)$. However, the biggest deterrent in keeping these students from entering regular university freshman- level mathematics classes for credit was their lack of knowledge of linear and quadratic equations and the formulas for these equations.

Faculty members at UGA's Division of Developmental Studies are currently doing research to learn more about these students and to find effective ways of bridging the gap between high-school and college mathematics courses. These studies have so far yielded two main recommendations.

First, we recommend that before taking any entrance or placement tests necessary for admission to college, students receive a review of algebraic formulas with particular attention to applications of linear and quadratic equations. This review might be done at the high school during the spring of the students' senior year or during a short (one-week) review course during the summer at a university. It seems important that students receive either ongoing or intensive reviews before they enter college.

Second, we recommend that problems involving formulas, especially those relating to linear and quadratic equations, not be taught as isolated units of instruction. Instead, mathematics courses should offer extensive opportunities to apply these equations, thereby leading to a deeper understanding of the real meaning of a line, of slope, and of a function.

Moreover, once students have been exposed to a concept, items using that concept should appear on each subsequent mathematics test and in their homework, which would force students to integrate their knowledge base. Teachers might consider giving one linear or quadratic equations problem daily while they check their attendance rolls.

These suggestions may seem to be making too much of a few simple concepts. Furthermore, the intent is definitely not to accuse high-school mathematics teachers of ineffective teaching, for, in general, the teachers are doing a good job. The point is that review and focus on quadratic and linear equations could save certain college-bound students time and money they must spend in developmental studies courses. If more attention were placed on these concepts, then these students might be able to enter regular freshman mathematics courses at the university level and bypass developmental studies mathematics.